

Brief Report

Earth2Class: An Effective and Easily Duplicable Model for Providing a Broad Impact of Cutting-Edge Science, Teacher Professional Development, and Inspiration for High School Students

Michael J. Passow

Lamont-Doherty Earth Observatory of Columbia University, Palisades, NY 10964, USA; michael@earth2class.org

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Abstract: We describe Earth2Class, a professional development model that connects classroom teachers with research investigators so that they and their students can learn about cutting-edge discoveries, long before mention is included in textbooks. Teachers and students attending “live” programs at the Lamont-Doherty Earth Observatory of Columbia University or Zoom equivalents necessitated during the pandemic benefit through interactions that bring out the excitement of making new geoscience discoveries. Evidence of the effectiveness of Earth2Class (E2C) workshops is provided through reflections of the impact of E2C on student career choices, expanding teacher content knowledge, and attitudes provided by teachers, students, parents, and scientists.

Keywords: Earth system sciences education; professional development; inspiring student career choices; broader research outreach strategies

1. What Purposes Do an Earth2Class Program Provide?

Most students believe that science textbooks convey a complete description of everything known about the subject. The word “text” itself is derived from the Latin word for “tissue,” in the sense of being woven of many threads. Research scientists are well-aware that there will never come a time when everything about a subject is known and can be summarized in one volume. One of the biggest challenges in science education is to assist our students toward understanding that there is a great distance between what scientists are exploring and what they learn through textbooks, that there is still much unknown in all branches of science, and that they might become the future discoverers of currently unasked questions.

Earth2Class (E2C) is based on providing students and teachers with role models, just as aspiring athletes or dancers watch professionals in their fields. However, most science research is not conducive to spectators. We have developed a model that enables high school and middle school students to meet research scientists and to learn directly from them about how they develop questions for investigations and the methods they use, as well as their recent discoveries.

Unfortunately, many classroom teachers never have opportunities to engage in rigorous scientific research, and so it is hard for them to instill in their students the excitement of making cutting-edge discoveries.

Since the winter of 1998, we have organized workshops once or twice a month at the Lamont-Doherty Earth Observatory of Columbia University called “Earth2Class” (E2C, a short-hand version of our motto, “Bringing the Earth to the Classroom” [1]). Lamont is a world-famous center for research in the geosciences, the home of many investigatorss who are among the most prestigious in their fields, as well as the home for graduate students in Columbia’s Department of Earth and Environmental Science—many of whom are future leaders. To date, we have offered 195 programs

involving more than 100 LDEO researchers (many enjoy returning year after year). Programs were offered, pre-Pandemic, in the Lamont Seismology Seminar Room, giving students and teachers a taste of how Lamont scientists and graduate students share their research amongst themselves. This setting is quite different from the classrooms they are used to. E2C has been an effective way for scientists to meet the “broader impact” requirements of National Science Foundation grants but has never been described in JGE.

2. What Happens in an Earth2Class Program?

The format for Earth2Class is fairly simple and has been developed over many years into the following arrangement for “live” workshops: Each in-person session begins on a Saturday morning at about 8:30 a.m. with the opportunity for participants to socialize over “caffeine and carbs” (coffee and bagels). This allows students to connect with peers. Many who choose to attend such programs often feel somewhat alienated in school because their keen interest in science isolates them from many peers. At about 9:30 a.m., a 15-min introductory slideshow is provided that gives participants a general background understanding of the topic and helps ensure they understand key vocabulary that will be used by the scientist.

By about 10:00 a.m. or 10:30 a.m., the scientist begins his/her presentation, which extends over the next two hours. Participants feel very comfortable to interject questions, some occasionally leading to new research projects.

Around noon, we break for “lunch with the scientist” (usually pizza and salad), which helps students and teachers feel a greater sense of connectedness with the scientist, part of helping them use this investigator as a role model for future experiences.

In many sessions, we continue during the afternoon with hands-on activities related to the topic. This gives teachers something they can bring back to their classrooms [2,3].

Beginning in March 2020, the E2C program, like many other instructional programs, switched to a Zoom-based structure. This will continue through at least the fall 2020 semester at the request of the Columbia administration. Sessions usually run from 10 a.m. to 11:30 a.m., with more limited participant–scientist interaction, which participants have indicated that they miss. However, this format has enabled others who cannot attend in-person to join us, increasing enrollment, and in the future may allow us to expand the pool of presenters to scientists outside of the Lamont researchers.

3. What Kinds of Topics Are Presented Through E2C?

Lamont research covers the entire globe (and sometimes beyond Earth) and a wide temporal scale. Selected examples of recent presentations and those to come in the academic year include: “Diversity and Inclusion in the Geosciences”; “Why are Arc Magmas so Rich in Silica?”; “Impact of the Amazon River Plume on Nitrogen Availability and Planktonic Food Webs in the Western Tropical Atlantic Ocean”; “Using Sediments Melted Out of Icebergs to Understand Antarctica’s Glacial History”; “Lead Contamination in Our Environment”; “Paleoclimatology Revealed through Tree Rings,” and “Improving Estimates of the Times of Volcanic Eruptions and Solving the Riddle of the Source Volcano for 536 A.D. [4,5].”

For later viewing and for those unable to attend the in-person programs, we have created the E2C website at <https://earth2class.org/site>. We plan to record the Zoom sessions and attach them to the website, which will further expand the effectiveness of the outreach. The site pages include archived versions of the slideshow presented during the workshop, links to pertinent sites, and sample classroom lessons. The E2C website has averaged more than 29,000 hits per month, even though we have not had a “live” workshop since February 2020.

On occasion, we have had scientists from other institutions who has collaborated with LDEO researcher as the E2C presenter [6]. With the use of zoom conferencing, we may expand this outreach further in future session.

4. What Is the Cost of an E2C Session?

E2C programs are very cost-effective. Columbia has donated the use of one of their seminar rooms, a setting that especially impresses the students who may have never been on a college campus before. Many scientists include an E2C program in NSF grant proposals as part of their broader impact strategies, but others have volunteered to present, even without funding available from research grants. Teachers usually pay a nominal \$10 or \$15 per session, which covers the cost of the refreshments and lunch (usually about \$130–\$160 per session), while students are accepted for free.

There are no charges for Zoom-based sessions, as we attempt to continue to encourage participants during this pandemic.

5. What do Teachers Get for Participating in E2C?

Each attendee receives a certificate of participation. Some school districts have used these as proof of meeting continuing education requirements. Through arrangements with St. Thomas Aquinas College located near Lamont, participants can opt to pay a special tuition rate and receive graduate education credits.

6. What Additional Benefits does E2C Offer?

The E2C program has been an effective “resource exchange.” Some participants are senior teachers nearing the end of their career, now seeking to pass on their classroom materials to teachers starting out who often lack what they need to be effective educators. E2C participants have brought in books, rocks, minerals, and fossils, which have gone home with happy younger colleagues. They also receive early notification of professional development opportunities through special e-lists. This has been a win–win for all.

When on campus, we have been able to arrange for special visits to Lamont research facilities, especially the Lamont Core Repository, one of the greatest collection of deep-sea sediments in the world (<https://www.ldeo.columbia.edu/core-repository>).

Another benefit of participating in E2C has been developing a corps of reliable and known classroom teachers and students that we can turn to when opportunities arise. Messages sent to the E2C participants have produced suitable candidates for field experiences, including summertime research in the Arctic and the Hudson River. Several of the high school students who attended E2C were subsequently selected by Lamont scientists for summer and school year internships, which significantly influenced their college decisions (see some of their reflections below).

E2C has opened opportunities to share resources developed through other science programs. For example, to enhance reading and writing skills, we created “Tales of the Resolution” reading activities (<https://joidesresolution.org/wp-content/uploads/2014/03/TOR-reading-overview.pdf>), based on graphic novels created by Carl Brenner, an E2C presenter.

7. What Have Been Examples of the Impact of E2C Participation?

The proof of any program is the impact on participants. We surveyed LDEO scientists, Earth sciences teachers, and students and their parents who have participated over the years/decades. Here are some representative responses:

7.1. Research Scientist

“I have had the honor and privilege to work with the Earth2Class group several times over the past decade or so, giving lectures at LDEO about my experiences as a dendrochronologist and conversing with the science teachers who make their way to our campus for the weekend events, and also participating in overnight experiences for urban students. It has proven to be a most valuable experience for me, as I tend to learn as much from the participants as I hope they learn from me. I also see how influential these sessions are for these science

educators from high schools and universities around the eastern seaboard, who are eager to engage with researchers from various fields to learn as much as they can about the science we are doing. I am quite certain that their engagement in E2C translates into much better experiences for their students upon their return.”

“I have frequently encouraged the young researchers in my group to engage with E2C and similar programs, as the next cohort of scientists to come up through the ranks will likely have been touched by this program in some way.”

(B. Buckley, Lamont Tree Ring Lab)

7.2. Students

“I started taking Earth2Class in my junior year of high school in 2017. It was wonderful to meet Dr. Passow when he visited my high school. At that time, I was not quite sure what I was interested in, as I was broadly interested in the sciences and medicine. But he urged me to attend an E2C session, so I went to one. I enjoyed getting to meet enthusiastic Earth sciences teachers and other high school students curious about Earth sciences. Early in the morning, before the session started, all of us participants met over a bagel and coffee breakfast, made some introductions, and chatted about what brought us to E2C. At the time, only one other high school student was coming to the classes. She was a lot more interested in the subject than I was, but it was fun to talk to her, and I felt inspired by her enthusiasm. Many of the teachers there were regular students at E2C because they loved learning and wanted to incorporate more material into their Earth sciences classes. I had the opportunity to continue my conversations with them at lunch. I would say that my small interest in Earth sciences grew greatly after spending time with them and participating in such exciting classes. Most of the science classes I took in high school were taught in a boring, textbook-focused fashion. My school did not even have an Earth sciences class (after Dr. Passow retired), so I never had an adult mentor or similarly interested classmates to help foster my interests in the subject of Earth sciences. (Unfortunately, after Dr. Passow retired from teaching, my school did not hire a new Earth sciences teacher.) Besides our breakfast and lunchtime, the classes and topics of E2C programs were all exciting.”

“My favorite program dealt with deep-sea core drilling and microfossils topic. Nicole Kurtz, an outreach coordinator from the International Ocean Discovery Program (IODP), taught us about what they do on the JOIDES Resolution ocean drilling ship and also about the unique opportunities teachers have to actually join the adventure and work onboard the ship towards outreach and education. In the afternoon, we enjoyed some classroom activities such as a microfossil identification game and studying sections of cores that demonstrate the Cretaceous impact. Then we were able to tour the LDEO Core Repository. Getting to see the vast collection of hundreds of cores was inspiring. Some were in the dry lockers and some in the freezer lockers, where it was so cold that researchers wear winter gear to work inside, all year round. The cores were beautiful in their variety, and the macroscopic appearance, such as color and texture, already showed the differences between sections, which record different periods in geologic history. I was so interested that I revisited the Core Repository to ask if I may work for them as an intern during my senior year in high school; a request that was granted. I am so grateful for E2C because it allowed me to connect with such an incredible opportunity. Having that experience in my senior year of high school was vital to my growth as a student and scientist, and was also my favorite part of the school year.”

(T. Shore)

“I first learned about the Earth2Class workshops when I accidentally met Dr. Passow while kayaking the summer of my freshman year of high school. I always had an interest in weather and aspects of the environment, but my school did not offer classes that helped me further

explore my interests. Going to his Earth2Class workshops from that time on introduced me to a diverse community of Earth sciences teachers, research scientists, and other students from the New York Metropolitan area, who both shared my interests and shared knowledge and ideas of the Earth that I never thought of before. I was able to learn more about topics such as tectonics and climate change, while networking with professionals in the field and making new friends.”

“Alongside learning and connecting with others, Earth2Class opened the doors to many amazing opportunities for exploration and research, public speaking, and community service. Dr. Passow really helps students get involved around Lamont-Doherty Earth Observatory and with other organizations. My first experience that stemmed from attending Earth2Class was being selected to explore the fjords and glacial lagoons in Alaska through a program called “Girls on Ice” (Inspiring Girls Expeditions), which was recommended to me by a teacher I met at the workshops. I have also been able to volunteer and share the research I conducted at the campus open houses for the last three years and participate in conferences that shared my findings. I enjoyed an internship with Lamont-Doherty’s Polar Geophysics Group during my senior year, thanks to Dr. Passow and what I have learned from the workshops.”

“I can easily say that Earth2Class formed the start of my Earth sciences education and has been a major influence on my new interests and career choices, as well as a home base for mentorship, guidance, and opportunities in the field. Even as we move solely to an online platform, we still learn and engage as much online as we did in-person months and years ago. I am now a second-year geology major with a double minor geography and marine science at Rutgers University. I am also a manager in training for the Rutgers Geology Museum, a research technical assistant for a glaciology research group, and an Earth2Class workshop attendee. Many of the scientists and teachers I know and work with today know me from my connections with Dr. Passow and Earth2Class, which I am very thankful to attend and learn from as a mentor. I would recommend any student interested in the wide range of Earth sciences—from rocks and minerals to marine sciences and the environment—to log into to the Zoom meetings that are available and learn something (or meet someone) new.”

(J. Berry)

“The Earth2Class lectures have been very instrumental in shaping my experience in science. Not only have I learned about the various specific content topics presented during the lectures, but I have also learned about the ways in which research is conducted. I discovered how scientists investigate, prepare, conduct, and present their original research ideas. Overall, the Earth2Class program has positively influenced my view of science and has provided insights that guide me in my goal of becoming a scientist.”

(A. Howard)

“The Earth2Class lectures have had a major impact on my own science research project. Through Dr. Passow and the Earth2Class program, I was able to meet and speak with many professional scientists. I met the lecture presenters, as well as teachers and other students interested in science. Because of E2C, I was able to find a mentor to assist me in conducting my own senior year authentic research project: I used python programming language to code a model of flexure that occurs on Europa, under the mentorship of a senior Lamont scientist.”

(N. Bauco)

7.3. Father of a Student

“My daughter expressed an interest in Earth sciences from an early age. We often attended the annual open houses at the Lamont-Doherty Earth Observatory. These visits deepened her interest, but were only “passive,” with little opportunity to interact meaningfully with what happens at Lamont. During her second year in high school, we learned about the E2C workshops organized by Dr. Passow. These sessions were an opportunity to expose students to a variety of cutting-edge Earth sciences research projects by accomplished scientists. The presentations were informative and gave students the opportunity to interact with scientists and Earth sciences teachers in a relaxed, informal setting. Access to Earth sciences professionals is not common. E2C gave my daughter the opportunity to get a first-hand look at what it is to work in different specialties of Earth sciences. I know that her experience in attending E2C workshops inspired her to apply for and enjoy a summer internship at Lamont, where she met other students interested in Earth sciences for the first time. She is now in her second year studying environmental science at McGill University. E2C was the seed that has led her to pursue this course of study and career path. I am grateful she had the opportunity and hope, and encourage other students and teachers to attend programs like E2C.”

(J. Lederer, father)

7.4. Classroom Teachers

“I taught chemistry and Earth sciences for 37 years and was starting to get bored. Then I learned about the E2C programs and began to find new ideas to include in my classes. About 15 years ago, I was among several E2C participants invited to attend the AGU annual meeting in San Francisco and present papers and poster sessions on our work with the Lamont scientists. While at this workshop, I befriended a few staff members from both the Hawaii Volcano labs and the Alaska Volcano labs. I took it upon myself to journey to both Hawaii and Alaska at my own expense. There, I assisted in collecting lava samples in Hawaii, and analyzing gas samples from volcanoes in the Aleutian Island chain.”

“Subsequently, in Alaska, I took a side trip to Denali Park with my camera to take photos of what can only be called “heaven.” If not for the contacts I made at the monthly LDEO workshops with Earth2Class, these opportunities would never have happened.”

(J. Signorelli, 37-year high school educator)

“For the past eleven years, I’ve taught geoscience in New York City public high schools—without a background in geology. My undergraduate degree was in meteorology, and when I initially began the process to become a teacher in New York, I applied to get a license in physics. Imagine my surprise when I was told I was more qualified to teach about earthquakes and volcanoes, rocks, and minerals! Nearly everything I have learned in the field of geology has been either self-taught or learned through professional development—and a great deal of that has been through Earth2Class. Some of the teaching resources that I value the most, that I use on a regular basis, I learned about at Earth2Class workshops. One particular example is GeoMapApp (<http://www.geomapapp.org/>)—an extremely powerful, yet simple-to-use visualization tool developed at Lamont that has data sets and sample lessons on everything from seafloor spreading to Antarctic glaciers. Not only did Earth2Class participants learn about the program from one of the principal developers of the project, but also, we were even invited to give feedback on how to improve it for classroom use! This gave us a sense of empowerment rare in professional development programs.”

“In addition to resources that I use in the classroom, Earth2Class has also given me the opportunity to learn about cutting-edge developments in the geosciences directly from the

scientists themselves. The stories that they tell, through video and photos and (sometimes preliminary) data and self-deprecating jokes, have given me a deeper understanding of, and respect for, the process of doing science. It is messy, unpredictable, and frustrating, and requires a great deal of patience—but can be deeply rewarding, and deeply human. Many of my students come to my class with the belief that science is done by male individuals in white coats in solitary labs; Earth2Class is one way that I can help my students understand how adventurous and exciting and personal science can be.”

(S. Adams, early career middle school teacher)

“I have been attending Saturday sessions of Earth2Class for many years. I do not know how many programs I have seen, but it is a lot. It is always a pleasure to hear from the actual scientists who are in the field and doing the work. For me, it is important to keep up on the science, because our knowledge is continually advancing. The scientists who present are at the top in their field, and I feel privileged that they are willing to take their time—on a Saturday morning—to share their research with high school teachers. Sometimes we teachers can get stuck in our classrooms with our textbooks and the syllabus content that we are required to teach, so we forget the “other side of the coin”—the research done by people who provide that content. Although the current research is often above what is required to be taught, it helps me to keep up on the latest information in the field. Some of that information I am able to share with my students. Some is too complex. But it helps me to keep current in my understanding of the content area of Earth sciences. It helps me intellectually to get out of the high school curriculum for a little while.”

“Having lunch with the scientist is always pleasant. I think the public has misconceptions about science and scientists. Lunch helps us to realize that these are normal, nice people who happen to do science for a living. Afternoons are with my colleagues. It is nice to get to know teachers in other districts: to socialize, compare notes, and share ideas. No matter how long one teaches (34 years for me), there is always more to learn, ideas to improve, and new activities. I learn much from my younger colleagues, but occasionally, we old dogs can teach the puppies something too! A teacher should always strive to improve their teaching, and Earth2Class helps me to do just that.”

(R. Aubry, senior high school teacher)

8. How Might an E2C Program Be Expanded to Other Institutions?

Establishing a similar program elsewhere is very feasible, if research scientists are willing to share their time and expertise. It does also require an experienced classroom teacher who can help provide necessary information through the introductory slide shows and connect the science with State and National Science Education Standards.

9. E2C in Brazil

During the 2015–2016 academic year, Prof. Douglas Sathler of UFVJM (the Federal University of Vales do Jequitinhonha and Mucuri) in Diamantina, State of Minas Gerais, Brazil, spent a sabbatical year at Lamont. He learned about the Earth2Class program, and on his return home, invited me to visit him. Subsequently, we developed “E2C em Diamantina” (<https://earth2class.org/site/?p=12652>), which has provided opportunities for students and faculty at UFVJM to learn more about U.S. education and to share what they have been investigating. One of the differences between E2C em Diamantina and E2C at Lamont is that the food provided consists of rice and beans, not pizza and salad.

During an afternoon at the start of the 2017–2018 academic year, we hosted an E2C program at UFVJM. Prof. Danielle Piuze presented examples of how her students are making 3-D models of various landscapes in the region. Prof. Glauco José de Matos Umbelino demonstrated the use of drones

to explore local geography. Prof. Cláudio Marinho taught students techniques to use computer-based programs to create 3-D images of minerals.

In another program, Carolina Castro, a middle school teacher in the Bronx, NY and an E2C participant, accompanied me to Diamantina and gave a talk (in Spanish) to UFVJM students about her teaching experiences in New York City public schools.

Diamantina is quite different in socioeconomic terms from the New York metropolitan area where the E2C students and participants come. Many in Diamantina have not even visited their state capital, Belo Horizonte, or the Brazilian capital in Brasília. Thus, “E2C em Diamantina” has provided eye-opening glimpses of different worlds to the Brazilian and U.S. participants. We plan to continue such programs once travel becomes more available and safer in both countries and may take advantage of the flexibility Zoom conferencing can provide to enable some UFVJM faculty to present at an E2C.

The “E2C em Diamantina” website also includes the “uncomplicated Channel” (<https://www.canaldescomplicado.net/>), a series of nearly 20 short YouTube videos in Portuguese created by Prof. Sathler to help Brazilian students understand what goes into writing professional papers, something not often taught in Brazilian undergraduate universities

10. Conclusions

Earth2Class is an effective, inexpensive model that can be implemented at any research institution interested in conducting outreach to local teachers and students. The positive impact on high school and middle school students can be significant and long-lasting.

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